(12) UK Patent Application (19) GB (11) 2 248 963 (13) A

(43) Date of A publication 22.04.1992

(21) Application No 9121947.7

(22) Date of filing 16.10.1991

(30) Priority data
(31) 9022585 (32) 17.10.1990 (33) GB
9112292 07.06.1991

(71) Applicant
GEC Marconi Limited

(Incorporated in the United Kingdom)

The Grove, Warren Lane, Stanmore, Middlesex, HA7 4LY, United Kingdom

(72) Inventors
Carolyn Bowry
Michael George Clark
Paul Bonnett

(74) Agent and/or Address for Service
S A George
Central Patent Department (Wembley Off.), The General Electric Company p l c, Hirst Research Centre, East Lane, Wembley, Middlesex, HA9 7PP, United Kingdom

(51) INT CL[5]
G11B 3/70 7/24

(52) UK CL (Edition K)
G5R RB21 RB265 RB571 RB701 RB711 RB784 RB788
U1S S1387 S1397 S1557 S1567 S1569

(56) Documents cited
CN 8614886 A JP 04000076 A JP 02123532 A
US 4904066 A US 4853911 A US 4832456 A

(58) Field of search
UK CL (Edition K) G5R RB21 RB24A
INT CL[5] G11B
Online databases: WPI, INSPEC

(54) Compact discs

(57) A compact disc for providing a digital audio or video recording or for recording computer data by laser writing comprises a substrate (2) on which is deposited a layer (1) of a liquid crystal polymer material, preferably having a glass transition temperature above room temperature. Writing is effected by heating elemental areas of the material using a laser. A reflective layer (3) is preferably provided between the liquid crystal layer and the substrate. The record is erasable by heating the liquid crystal polymer material to its isotropic phase and then cooling it relatively slowly. In a second embodiment, a compact disc comprises two substrates (8, 9) between which is contained a layer (9) of a polysiloxane liquid crystal material which exhibits a light-scattering texture after heating with a laser beam. In each case, a dye may be incorporated in the liquid crystal material for efficient absorption of laser light of a predetermined wavelength during writing. Electrodes (10, 11) are provided on the inner surfaces of the substrates for applying an electric field to the polymer layer.

Fig. 1.

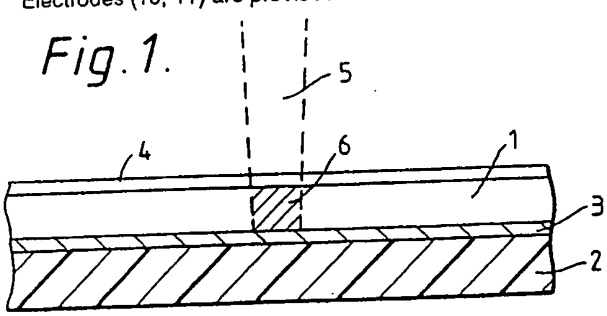
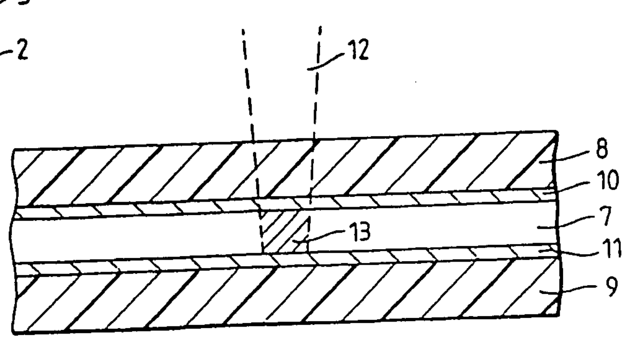


Fig. 2.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

GB 2 248 963 A

Fig. 1.

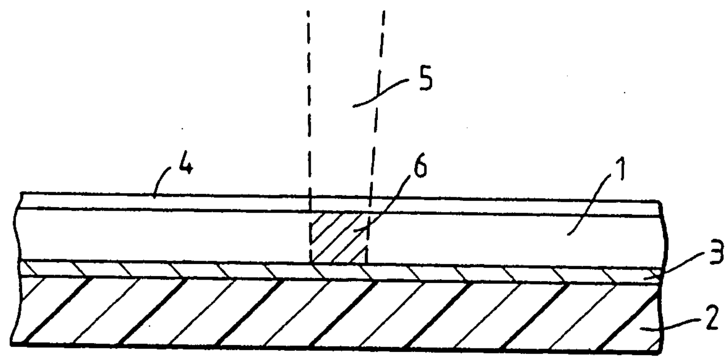
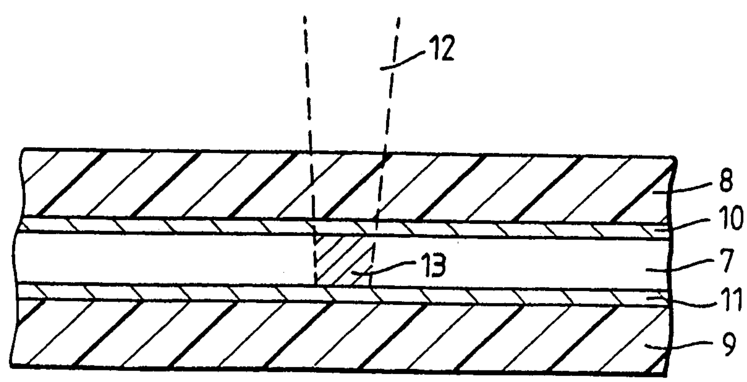


Fig. 2.



Compact Discs

This invention relates to compact discs.

Compact discs are well established as digitally-encoded read-only discs which are commonly used for high-quality sound reproduction. The conventional compact discs are produced by forming microscopic pits in a substrate by a stamping process. The substrate comprises a layer of transparent plastics material on a reflective support disc. The sound is reproduced by reading the pits using a low-power laser diode, and converting the resulting digital signal into an analogue signal.

These conventional discs are quite definitely read-only devices; they cannot be updated, nor can data be selectively erased therefrom.

It is an object of the present invention to provide an improved compact disc.

According to the invention there is provided a compact disc comprising as an optical storage medium a layer of liquid crystal polymer material.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawing, in which

Figure 1 shows a schematic cross section through one form of compact disc in accordance with the invention, and

Figure 2 shows a schematic cross section through a second form of compact disc in accordance with the invention.

Liquid crystals, in general, are unique materials which exhibit anisotropy of various physical properties, including refractive index and dielectric susceptibility. These properties allow liquid crystal (LC) materials to be controlled by electric fields and thereby to provide the responses commonly found in liquid crystal displays (LCDs).

Liquid crystal polymer (LCP) materials are a specific class of liquid crystal materials which exhibit these properties and additionally exhibit the potential advantages of conventional polymer materials, such as mechanical integrity and ease of processing. However, they have not been used in LCDs because they have a sluggish response to electric fields due to their high viscosity, even when heated.

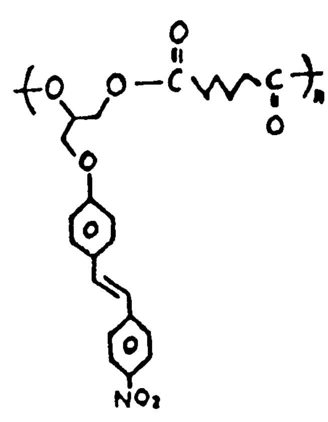
It is known that LCP materials can be used as thermo-optic and photo-optic storage media. The application of LCPs in the area of optical recording is of particular interest and these electro-responsive materials further offer the prospect of write once and erasability in recording media. While it is known that certain classes of low molar mass (non-polymeric) LCs, e.g. smectic A cyanobiphenyl mixtures, can also be implemented in erasable optical storage elements, the readily-available glassy phases, the high viscosity and the different handling properties available in the case of LCP materials make these materials particularly attractive. For example, with regard to a film-based product, the low molar mass smectic A LC storage media are useless, in spite of the fact that the technology for thin flexible plastic LCD production is already well known. This is so because of the limited viscosity range available in such media. Hence, when smectic A LC media are confined in flexible LCD formats, such as might be required in a micrographics application, and are then stressed mechanically, the data written thereon are corrupted due to the formation of scattering textures. These scattering textures originate at the source of the deformation and propagate across the recording field. Used in a rigid configuration in which they are contained between glass plates, on the other hand, these materials offer very high performance and have been successfully used in

ultrahigh resolution displays and artwork generators.

Unlike conventional LCs, LCP materials are high molecular weight materials which possess many of the properties of the actual plastics substrates which are used in plastic LCD manufacture. These electroactive polymers are therefore more compatible with such substrates, particularly when correctly engineered with respect to their phase behaviour. The scope for molecular engineering is a further advantage of LCP materials, this scope being broader than for the low molar mass materials, since polymers can be copolymerised, crosslinked, plasticised and form interpenetrating networks, etc. Furthermore, because of the size of their molecules, LCPs do not possess the powerful solvent characteristics exhibited by conventional LC materials, which present problems when using organic substrates.

Referring to Figure 1 of the drawing, in the manufacture of a compact disc in accordance with the invention, a layer 1 of a liquid crystal polymer material is deposited on a substrate 2 of, for example, a plastics material, preferably with a reflective layer 3 of, for example, aluminium therebetween. The substrate material may be, for example, polycarbonate, polyethylene terephthalate or polymethyl methacrylate. The material of the substrate may, without detriment, be birefringent, as the LCP material is not sensitive to polarisation. A cheap plastics material can therefore be used. A protective layer 4 is preferably deposited over the polymer layer 1.

The preferred LCP material is one which has a glass transition temperature (Tg) above room temperature, such as the polyacrylates and polyester-based LCPs. A suitable example is shown below.



For the above polymer, which has a nematic phase, the glass transition temperature (Tg) is 55°C and the clearing point temperature (Tc) is 90°C.

The optimum value of Tg for the liquid crystal polymer is approximately 100°C, because the stored information will then be stable close to this temperature, and the medium can be considered archivable. Polymers, such as that in accordance with the above formula, which have a lower Tg will nevertheless be usable.

The polymer material is solid at room temperature, and can readily be deposited on the substrate. In one suitable method of coating the substrate, the LCP material is dissolved in a solvent, such as cyclopentanone or methyl ethyl ketone at a 20% w.w. concentration. The solution is spread over the substrate using a doctor blade or a wire-wound rod, preferably producing an LCP layer of optimum thickness between 1 and 10 μm. The thinner the LCP layer the more sensitive it is to the laser energy during writing, but the lower the contrast of the resultant written spot against the background.

In order that the laser energy may be absorbed efficiently by the LCP material, a dye is incorporated in the material by, for example, mixing a suitable quantity of dye (for example 3%) into the polymer or by covalently attaching the dye on to the polymer backbone. The dye is optimised to suit the wavelength of the type of laser which is to be used for writing. For example, the wavelength will be 633nm for a He-Ne laser or 820nm/680nm for a laser diode.

The substrate is cut into the required disc shape either before or after coating with the LCP material.

The LCP material is then initialised to render the material scattering. This initialisation can be effected by heating the material into its isotropic phase, cooling it into its liquid crystal phase, maintaining the temperature until the material is densely scattering, and then cooling it into its glass phase. A suitable initialisation process is described in greater detail in copending British Patent Application No. 9019542.1. The initialisation may be combined with the drying of the LCP layer if a

polymer/solvent solution is used for deposition of the layer.

In order to write data into the disc, a laser beam 5 is focused on to an elemental area 6 of the LCP material and the material in that area is rapidly heated thereby into the isotropic phase and becomes clear. On removal of the beam the material rapidly cools to room temperature and quenches into the glass phase without having sufficient time to reorientate into the liquid crystal phase. The written spot therefore remains in a clear isotropic state. The difference between the scattering texture of the unwritten background and the clear texture of the written spot gives a high signal to noise ratio during reading of the data.

The laser beam energy density required for writing a spot is 1nJ/μm^2. The standard pit size for an audio compact disc is 0.6 μm wide x 1μm long. To write one spot of that size in the polymer in 1us therefore requires a laser beam power of 1nW if the focused laser beam is 1μm diameter. This low power requirement enables a visible light (680nm) or infra-red (820nm) laser diode to be used for writing. A visible-light diode is preferable, because a smaller diffraction-limited spot is possible and, furthermore, the laser is safer to use. Faster bit rates can be achieved by increasing the power delivered to the writing spot by the laser.

The production of a clear written spot in a scattering background, which is achieved by using an LCP material, is the opposite of the effect which would be obtained using a low molar mass liquid crystal material. Such materials assume a scattering texture when written by heating with a laser beam. The liquid crystal polymer materials which quench into a clear state after heating have the advantages that no alignment of the liquid crystal is required and it is not necessary to apply an electric field to the material either during writing or for initialising. A computer disc using a liquid crystal polymer material as the storage medium is therefore cheap to manufacture and is reliable. Erasure of the written data can be effected by heating the LCP material into its isotropic phase and cooling it relatively slowly. Bulk erasure of data from a disc is therefore possible.

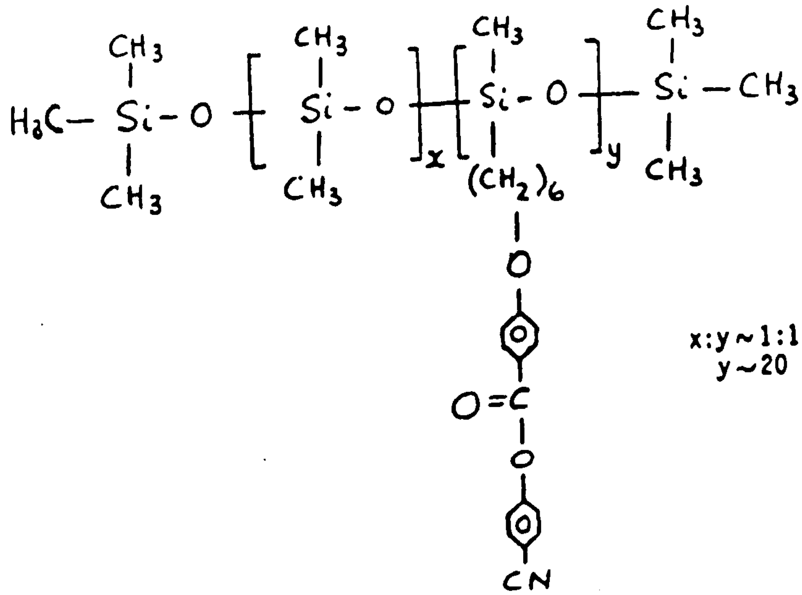
Since the information is stored in the glass phase of the

LCP material, the disc is archivable.

The substrate of the disc may be formed from either rigid or flexible plastics material, so that either rigid or floppy discs may be produced.

Referring to Figure 2 of the drawing, in the manufacture of a second form of compact disc in accordance with the invention, a layer 7 of LC polymer is disposed between two rigid substrates 8 and 9. The material of the substrates may be a polymer, for example polycarbonate, polyethylene terephthalate, polymethyl methacrylate; or may be glass. The substrate 8 may be thinner than the substrate 9 in order to reduce optical effects when writing with a laser. The substrates may also be of different materials. The material of the substrates may be birefringent without detriment, since the LCP material is not sensitive to polarisation. A cheap plastics material may therefore be used as the substrate material. Electrodes 10 and 11 must be provided on the inner surfaces of the substrates in order to apply an electric field across the LCP layer. The electrode 10 must be transparent to the laser beam, and a suitable electrode material is indium tin oxide, as used in LCD displays. The electrode 11 may be a reflective layer, such as aluminium.

The preferred LCP material in this case is one which has a glass transition temperature (Tg) well below room temperature (for example $< 0°C$).
Polysiloxanes are suitable for this purpose, since they have a flexible backbone, with the result that Tg for these materials is low. In particular, copolysiloxanes with $-CH_3$ and mesogenic moieties as side chains are preferable. An example of a suitable copolysiloxane is shown below.



x:y ~ 1:1
y ~ 20

For the above polymer, which has a smectic A phase, Tg is -8°C and the clearing point is 80°C.

In order to write data into the disc, a laser beam 12 is focused on to an elemental area 13 of the LCP material and the LCP material is rapidly heated into the isotropic phase. On removal of the beam, the material cools slowly to room temperature and the LCP exhibits a scattering texture when it is in the LC phase. The written spot can be erased by reapplying the laser beam to reheat the LCP material into the isotropic phase. The material then cools with an electric field applied to it by means of the electrodes 10 and 11, so that the field reorientates the LC material to an aligned state. This state is optically clear. The contrast between the scattering texture and the aligned texture gives a high signal-to-noise ratio during subsequent reading of the data.

In order that the laser energy may be absorbed efficiently by the LCP material, a dye is incorporated in the material as described above.

The initial state of the LCP material is not important. The background can therefore be scattering, or aligned by means of an electric field. However, a scattering background is preferable and will avoid the risk of electrical shorting which might occur during bulk alignment using an electric field. Erasure of the entire data

content of the disc can then be easily achieved by heating the whole disc into the isotropic phase and allowing the LC material to cool naturally into a scattering state. The initial writing or the selective erasing could be effected using an applied electric field. For example, if the initial writing were effected with an electric field applied to the LC material, the written spots would be aligned. To erase a spot selectively, the spot would be readdressed using the laser beam but with no applied electric field, so that the spot would become scattering. If the initial writing were effected without an electric field applied, the spot would be scattering and selective erasure would require the application of an electric field.

It will be apparent that compact discs in accordance with the invention may be used to store information in various forms. Such a disc may contain, for example, a digital audio or video recording or computer data. A digital audio recording on such a disc will be playable using a conventional compact disc player.

Unlike magneto-optic discs or metal phase-change discs, an LCP disc is environmentally stable. There is no degradation due to contact with moisture or air, and the disc can be safely handled in a normal room environment. LCP discs are therefore significantly cheaper to manufacture than magneto-optic or phase-change discs.

Claims

1. A compact disc comprising as an optical storage medium a layer of liquid crystal polymer material.

2. A compact disc as claimed in Claim 1, wherein the liquid crystal polymer material has a glass transition temperature above room temperature.

3. A compact disc as claimed in Claim 2, wherein the liquid crystal polymer material is a polyacrylate.

4. A compact disc as claimed in Claim 2, wherein the liquid crystal polymer material is a polyester.

5. A compact disc as claimed in any preceding claim, wherein the layer of liquid crystal material is deposited on a substrate.

6. A compact disc as claimed in Claim 5, wherein the substrate is formed of a plastics material.

7. A compact disc as claimed in Claim 6, wherein the plastics material is flexible.

8. A compact disc as claimed in Claim 6, wherein the plastics material is polycarbonate, polyethylene terephthalate or polymethyl methacrylate.

9. A compact disc as claimed in any one of Claims 5-8, wherein a reflective layer is disposed between the layer of liquid crystal material and the substrate.

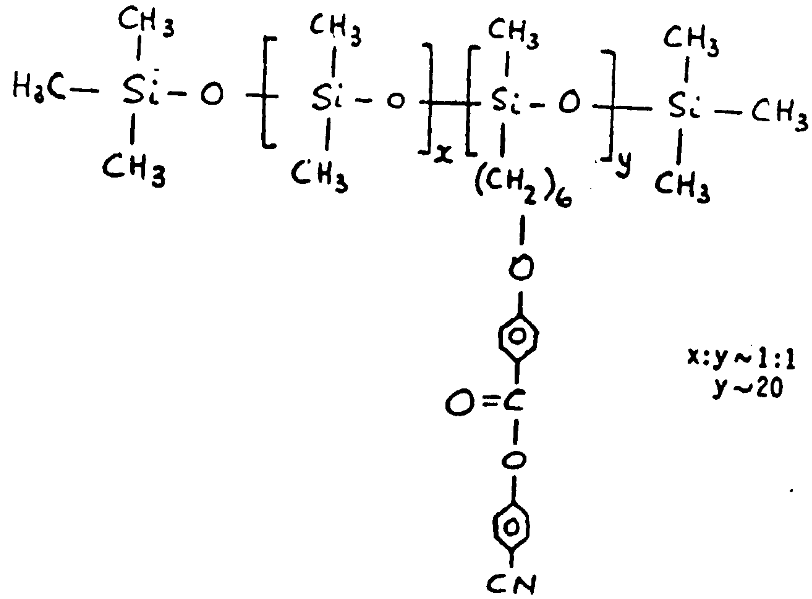
10. A compact disc as claimed in Claim 9, wherein the reflective layer comprises a layer of aluminium.

11. A method of manufacturing a compact disc as claimed in any one of Claims 6-10, wherein the layer of liquid crystal polymer material is initialised by heating to render the material optically scattering.

12. A method as claimed in Claim 11, wherein the liquid crystal polymer material is dissolved in a solvent and the solution is spread on the substrate using a doctor blade.

13. A compact disc as claimed in Claim 1, wherein the polymer material is a polysiloxane liquid crystal polymer.

14. A compact disc as claimed in Claim 13, wherein the liquid crystal polymer is a copolysiloxane of the form:-



x:y ~ 1:1
y ~ 20

15. A compact disc as claimed in Claim 13 or Claim 14, wherein the polymer material is contained between two substrates.

16. A compact disc as claimed in Claim 15, wherein a respective electrically-conductive layer is provided on a surface of each substrate in contact with the polymer material for applying an electric field to said material.

17. A compact disc as claimed in Claim 16, wherein at least one of the electrically-conductive layers is formed of indium tin oxide.

18. A compact disc as claimed in Claim 16 or Claim 17, wherein one of the electrically-conductive layers is light-reflective.

19. A compact disc as claimed in Claim 18, wherein the light-reflective layer is formed of aluminium.

20. A compact disc as claimed in any preceding claim, wherein a dye is incorporated in the polymer material, the dye being selected for efficient absorption of light of a predetermined wavelength.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number

9121947.7

Relevant Technical fields

(i) UK Cl (Edition K) G5R (RB21,RB24A)

(ii) Int Cl (Edition 5) G11B

Search Examiner

A J RUDGE

Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASES : WPI, INSPEC

Date of Search

27 NOVEMBER 1991

Documents considered relevant following a search in respect of claims 1-20

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
Y	US 4904066 (GEC)	14 at least
X	US 4853911 (Semiconductor Energy)	ALL
X	US 4832456 (Semiconductor Energy)	ALL
X	CN 86104886 (Semiconductor Energy)	ALL
X	JP 2123532 A (Canon)	ALL
X	JP 64000076 A (Nippon KK)	ALL

SF2(p) tp - c:\wp51\doc99\fil000081

12

Category	Identity of document and relevant passages	Relevant to cl[illegible]

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Pat nt document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

Published 1992 at The Patent Office, Concept House, Cardiff Road, Newport, Gwent NP9 1RH. Further copies may be [illegible]
Sales Branch, Unit 6, Nine Mile Point, Cwmfelinfach, Cross Keys, [illegible]